

## Supplemental Material

### Environmental Inequality in Exposures to Airborne Particulate Matter Components in the United States

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Supplemental Material Table S1. Average ( $\pm$  standard deviation) estimated exposure to PM<sub>2.5</sub> total mass and PM<sub>2.5</sub> chemical components in the U.S., overall and by age [ $\mu\text{g}/\text{m}^3$ ]

Population or Pollutant	Total Population	Age		
		$\leq 19$ yrs	20 to 64 yrs	$\geq 65$ yrs
Population	867,815	250,927	511,921	104,967
PM <sub>2.5</sub> total mass	13.4 $\pm$ 2.87	13.5 $\pm$ 2.87	13.3 $\pm$ 2.86	13.4 $\pm$ 2.90
Al	0.0335 $\pm$ 0.0291	0.0350 $\pm$ 0.0319	0.0331 $\pm$ 0.0280	0.032 $\pm$ 0.0274
NH <sub>4</sub> <sup>+</sup>	1.39 $\pm$ 0.545	1.41 $\pm$ 0.541	1.38 $\pm$ 0.547	1.41 $\pm$ 0.544
Ca	0.0561 $\pm$ 0.0425	0.0587 $\pm$ 0.0467	0.0553 $\pm$ 0.0407	0.0542 $\pm$ 0.0398
Cl	0.0342 $\pm$ 0.0477	0.0353 $\pm$ 0.0488	0.0340 $\pm$ 0.0472	0.0325 $\pm$ 0.0470
EC	0.618 $\pm$ 0.266	0.621 $\pm$ 0.267	0.619 $\pm$ 0.264	0.612 $\pm$ 0.268
Ni	0.0016 $\pm$ 0.0019	0.0016 $\pm$ 0.0019	0.0016 $\pm$ 0.0019	0.0015 $\pm$ 0.0017
NO <sub>3</sub> <sup>-</sup>	1.64 $\pm$ 1.14	1.70 $\pm$ 1.20	1.61 $\pm$ 1.11	1.60 $\pm$ 1.09
OCM	3.75 $\pm$ 1.36	3.77 $\pm$ 1.37	3.75 $\pm$ 1.35	3.71 $\pm$ 1.38
Si	0.112 $\pm$ 0.0809	0.116 $\pm$ 0.0878	0.110 $\pm$ 0.0780	0.108 $\pm$ 0.0768
Na <sup>+</sup>	0.149 $\pm$ 0.0823	0.150 $\pm$ 0.0850	0.149 $\pm$ 0.0820	0.145 $\pm$ 0.0769
SO <sub>4</sub> <sup>=</sup>	3.18 $\pm$ 1.30	3.16 $\pm$ 1.28	3.17 $\pm$ 1.30	3.26 $\pm$ 1.32
Ti	0.0044 $\pm$ 0.0025	0.0045 $\pm$ 0.0027	0.0044 $\pm$ 0.0024	0.0043 $\pm$ 0.0024
V	0.0018 $\pm$ 0.0014	0.0019 $\pm$ 0.0014	0.0018 $\pm$ 0.0014	0.0017 $\pm$ 0.0013
Zn	0.0146 $\pm$ 0.0196	0.0152 $\pm$ 0.0214	0.0142 $\pm$ 0.0187	0.0148 $\pm$ 0.0193

Supplemental Material Table S2. Average ( $\pm$  standard deviation) estimated exposure to PM<sub>2.5</sub> total mass and PM<sub>2.5</sub> chemical components in the U.S., overall and by race/ethnicity categories [ $\mu\text{g}/\text{m}^3$ ]

<i>Population or Pollutant</i>	<i>Non-Hispanic white</i>	<i>Non-Hispanic Black/African-American</i>	<i>Non-Hispanic Asian</i>	<i>Hispanic</i>	<i>Other race</i>
Population	555,853	155,159	26,066	108,560	22,177
PM <sub>2.5</sub> total mass	13.1 $\pm$ 2.81	14.4 $\pm$ 2.08	12.7 $\pm$ 3.47	13.6 $\pm$ 3.48	12.8 $\pm$ 3.26
Al	0.0296 $\pm$ 0.0190	0.0313 $\pm$ 0.0152	0.0306 $\pm$ 0.0288	0.0573 $\pm$ 0.0601	0.0341 $\pm$ 0.0259
NH <sub>4</sub> <sup>+</sup>	1.38 $\pm$ 0.536	1.4 $\pm$ 0.417	1.22 $\pm$ 0.656	1.38 $\pm$ 0.672	1.25 $\pm$ 0.619
Ca	0.0502 $\pm$ 0.0291	0.052 $\pm$ 0.0323	0.0547 $\pm$ 0.0401	0.0916 $\pm$ 0.0802	0.0604 $\pm$ 0.0398
Cl	0.0273 $\pm$ 0.0389	0.0299 $\pm$ 0.0442	0.0554 $\pm$ 0.052	0.0689 $\pm$ 0.0705	0.0420 $\pm$ 0.0442
EC	0.564 $\pm$ 0.246	0.700 $\pm$ 0.267	0.738 $\pm$ 0.297	0.745 $\pm$ 0.270	0.659 $\pm$ 0.253
Ni	0.0014 $\pm$ 0.0016	0.0015 $\pm$ 0.0017	0.0023 $\pm$ 0.0023	0.0025 $\pm$ 0.0029	0.0017 $\pm$ 0.0018
NO <sub>3</sub> <sup>-</sup>	1.58 $\pm$ 1.00	1.36 $\pm$ 0.826	1.91 $\pm$ 1.44	2.23 $\pm$ 1.71	1.73 $\pm$ 1.21
OCM	3.57 $\pm$ 1.41	4.08 $\pm$ 1.02	3.92 $\pm$ 1.24	4.15 $\pm$ 1.33	3.91 $\pm$ 1.49
Si	0.101 $\pm$ 0.0564	0.104 $\pm$ 0.0465	0.102 $\pm$ 0.0766	0.178 $\pm$ 0.159	0.114 $\pm$ 0.0746
Na <sup>+</sup>	0.136 $\pm$ 0.0698	0.148 $\pm$ 0.0703	0.193 $\pm$ 0.101	0.199 $\pm$ 0.119	0.159 $\pm$ 0.0884
SO <sub>4</sub> <sup>=</sup>	3.20 $\pm$ 1.34	3.77 $\pm$ 0.841	2.47 $\pm$ 1.29	2.49 $\pm$ 1.16	2.66 $\pm$ 1.36
Ti	0.0040 $\pm$ 0.0018	0.0043 $\pm$ 0.0017	0.0050 $\pm$ 0.0033	0.0065 $\pm$ 0.0044	0.0046 $\pm$ 0.0024
V	0.0016 $\pm$ 0.0011	0.0020 $\pm$ 0.0016	0.0027 $\pm$ 0.0019	0.0027 $\pm$ 0.0018	0.0020 $\pm$ 0.0015
Zn	0.0128 $\pm$ 0.0153	0.0183 $\pm$ 0.0311	0.0133 $\pm$ 0.0113	0.0179 $\pm$ 0.0164	0.0178 $\pm$ 0.0263

Supplemental Material Table S3. Long-term average ( $\pm$  standard deviation) estimated exposure to PM<sub>2.5</sub> total mass and PM<sub>2.5</sub> chemical components in the U.S., by educational attainment and employment status [ $\mu\text{g}/\text{m}^3$ ]

Population or Pollutant	Educational Attainment			Employment Status		
	< High school	High school	College	Unemployed	Employed	Non-Jobseeker
Population	130,611	164,169	249,517	32,069	382,572	258,724
PM <sub>2.5</sub> total mass	13.8 $\pm$ 2.90	13.4 $\pm$ 2.77	13.0 $\pm$ 2.85	13.5 $\pm$ 2.98	13.2 $\pm$ 2.87	13.5 $\pm$ 2.84
Al	0.0365 $\pm$ 0.0343	0.0314 $\pm$ 0.0245	0.0319 $\pm$ 0.0269	0.0352 $\pm$ 0.0287	0.0322 $\pm$ 0.0272	0.0342 $\pm$ 0.0294
NH <sub>4</sub> <sup>+</sup>	1.43 $\pm$ 0.554	1.42 $\pm$ 0.530	1.35 $\pm$ 0.546	1.39 $\pm$ 0.564	1.37 $\pm$ 0.546	1.40 $\pm$ 0.539
Ca	0.0623 $\pm$ 0.0521	0.0521 $\pm$ 0.0359	0.0535 $\pm$ 0.0365	0.0572 $\pm$ 0.0440	0.0537 $\pm$ 0.0385	0.0574 $\pm$ 0.0439
Cl	0.0391 $\pm$ 0.0528	0.0309 $\pm$ 0.0464	0.0326 $\pm$ 0.0450	0.0355 $\pm$ 0.0478	0.0326 $\pm$ 0.0457	0.0348 $\pm$ 0.0494
EC	0.666 $\pm$ 0.283	0.608 $\pm$ 0.272	0.599 $\pm$ 0.252	0.647 $\pm$ 0.277	0.602 $\pm$ 0.259	0.633 $\pm$ 0.269
Ni	0.0017 $\pm$ 0.0020	0.0015 $\pm$ 0.0016	0.0016 $\pm$ 0.0021	0.0016 $\pm$ 0.0019	0.0015 $\pm$ 0.0019	0.0015 $\pm$ 0.0018
NO <sub>3</sub> <sup>-</sup>	1.70 $\pm$ 1.28	1.57 $\pm$ 1.02	1.60 $\pm$ 1.05	1.65 $\pm$ 1.21	1.61 $\pm$ 1.08	1.60 $\pm$ 1.13
OCM	3.90 $\pm$ 1.30	3.69 $\pm$ 1.38	3.68 $\pm$ 1.37	3.92 $\pm$ 1.46	3.68 $\pm$ 1.35	3.80 $\pm$ 1.34
Si	0.120 $\pm$ 0.0944	0.105 $\pm$ 0.0697	0.107 $\pm$ 0.0749	0.116 $\pm$ 0.0804	0.108 $\pm$ 0.0761	0.114 $\pm$ 0.0815
Na <sup>+</sup>	0.154 $\pm$ 0.0894	0.142 $\pm$ 0.0760	0.148 $\pm$ 0.0793	0.148 $\pm$ 0.0828	0.147 $\pm$ 0.0806	0.149 $\pm$ 0.0816
SO <sub>4</sub> <sup>=</sup>	3.26 $\pm$ 1.24	3.32 $\pm$ 1.28	3.08 $\pm$ 1.34	3.14 $\pm$ 1.29	3.15 $\pm$ 1.32	3.24 $\pm$ 1.27
Ti	0.0048 $\pm$ 0.0029	0.0042 $\pm$ 0.0022	0.0043 $\pm$ 0.0023	0.0046 $\pm$ 0.0025	0.0043 $\pm$ 0.0023	0.0045 $\pm$ 0.0025
V	0.0020 $\pm$ 0.0015	0.0017 $\pm$ 0.0013	0.0018 $\pm$ 0.0014	0.0020 $\pm$ 0.0016	0.0018 $\pm$ 0.0014	0.0018 $\pm$ 0.0014
Zn	0.0169 $\pm$ 0.0228	0.0145 $\pm$ 0.0198	0.0131 $\pm$ 0.0157	0.0150 $\pm$ 0.0212	0.0137 $\pm$ 0.0177	0.0151 $\pm$ 0.0203

Supplemental Material Table S4. Long-term average ( $\pm$  standard deviation) estimated exposure to PM<sub>2.5</sub> total mass and PM<sub>2.5</sub> chemical components in the U.S., by poverty status and earnings [ $\mu\text{g}/\text{m}^3$ ]

Population or Pollutant	Poverty Status		Annual Earnings			
	Below Poverty	Above Poverty	<\$15,000	\$15,000-\$29,999	\$30,000-\$49,999	$\geq \$50,000$
Population	145,802	680,158	176,559	138,189	90,465	54,126
PM <sub>2.5</sub> total mass	13.7 $\pm$ 2.98	13.3 $\pm$ 2.86	13.2 $\pm$ 2.97	13.3 $\pm$ 2.89	13.2 $\pm$ 2.76	13.2 $\pm$ 2.60
Al	0.0374 $\pm$ 0.0331	0.0327 $\pm$ 0.0288	0.0344 $\pm$ 0.0289	0.0323 $\pm$ 0.0261	0.0310 $\pm$ 0.0258	0.0292 $\pm$ 0.0252
NH <sub>4</sub> <sup>+</sup>	1.37 $\pm$ 0.567	1.40 $\pm$ 0.547	1.34 $\pm$ 0.553	1.38 $\pm$ 0.550	1.39 $\pm$ 0.528	1.42 $\pm$ 0.525
Ca	0.0633 $\pm$ 0.0533	0.0548 $\pm$ 0.0403	0.0562 $\pm$ 0.0430	0.0533 $\pm$ 0.0370	0.0518 $\pm$ 0.0348	0.0525 $\pm$ 0.0342
Cl	0.0409 $\pm$ 0.0536	0.0334 $\pm$ 0.0469	0.0331 $\pm$ 0.0469	0.0323 $\pm$ 0.0452	0.0316 $\pm$ 0.0446	0.0334 $\pm$ 0.0451
EC	0.684 $\pm$ 0.282	0.608 $\pm$ 0.263	0.609 $\pm$ 0.260	0.612 $\pm$ 0.261	0.592 $\pm$ 0.253	0.595 $\pm$ 0.258
Ni	0.0017 $\pm$ 0.0019	0.0016 $\pm$ 0.0019	0.0014 $\pm$ 0.0017	0.0015 $\pm$ 0.0019	0.0015 $\pm$ 0.0018	0.0019 $\pm$ 0.0026
NO <sub>3</sub> <sup>-</sup>	1.62 $\pm$ 1.26	1.65 $\pm$ 1.12	1.57 $\pm$ 1.13	1.60 $\pm$ 1.09	1.62 $\pm$ 1.02	1.71 $\pm$ 0.987
OCM	4.04 $\pm$ 1.36	3.69 $\pm$ 1.36	3.79 $\pm$ 1.40	3.72 $\pm$ 1.33	3.60 $\pm$ 1.30	3.54 $\pm$ 1.24
Si	0.122 $\pm$ 0.0921	0.109 $\pm$ 0.0797	0.115 $\pm$ 0.0806	0.108 $\pm$ 0.0736	0.104 $\pm$ 0.0720	0.0989 $\pm$ 0.0696
Na <sup>+</sup>	0.159 $\pm$ 0.0908	0.147 $\pm$ 0.0815	0.147 $\pm$ 0.0812	0.147 $\pm$ 0.0811	0.145 $\pm$ 0.0773	0.149 $\pm$ 0.0809
SO <sub>4</sub> <sup>=</sup>	3.13 $\pm$ 1.27	3.18 $\pm$ 1.31	3.09 $\pm$ 1.32	3.19 $\pm$ 1.31	3.20 $\pm$ 1.29	3.20 $\pm$ 1.26
Ti	0.0049 $\pm$ 0.0028	0.0043 $\pm$ 0.0024	0.0045 $\pm$ 0.0025	0.0043 $\pm$ 0.0023	0.0041 $\pm$ 0.0022	0.0041 $\pm$ 0.0021
V	0.0021 $\pm$ 0.0016	0.0018 $\pm$ 0.0014	0.0018 $\pm$ 0.0013	0.0018 $\pm$ 0.0014	0.0017 $\pm$ 0.0014	0.0019 $\pm$ 0.0016
Zn	0.0170 $\pm$ 0.0249	0.0143 $\pm$ 0.0188	0.0139 $\pm$ 0.0187	0.0138 $\pm$ 0.0182	0.0134 $\pm$ 0.0165	0.0128 $\pm$ 0.0128

Supplemental Material Table S5. Comparison of population characteristics for census tracts with and without monitors for PM<sub>2.5</sub> chemical components

	<i>Population characteristics Mean ± standard deviation</i>		<i>% increase in probability of having PM<sub>2.5</sub> component monitor per 10% increase in population characteristic of census tract (95% confidence interval)</i>
	<i>Census tracts with monitors</i>	<i>Census tracts without monitors</i>	
<i>Population</i>	867,815	279,326,737	
<i>Number of census tracts</i>	215	64,413	
<i>Race</i>			
Non-Hispanic White	63.3% ± 31.6%	68.8% ± 30.3%	-5.4 (-9.2, -1.5)
Non-Hispanic Black	20.5% ± 28.6%	13.5% ± 23.5%	10.3 (5.5, 15.4)
Non-Hispanic Asian	2.74% ± 5.65%	3.35% ± 7.16%	-14.0 (-32.3, 9.2)
Hispanic	10.8% ± 17.2%	11.5% ± 18.9%	-2.2 (-9.3, 5.4)
Other	2.66% ± 2.67%	2.77% ± 5.62%	-4.0 (-26.7, 25.7)
<i>Age</i>			
≤19 years	28.4% ± 7.15%	28.2% ± 6.98%	3.4 (-14.7, 25.2)
20 to 64 years	59.1% ± 6.65%	58.8% ± 6.65%	6.3 (-12.8, 29.6)
≥65 years	12.6% ± 5.22%	13.0% ± 7.08%	-9.0 (-25.8, 11.5)
<i>Education</i>			
< High school	25.5% ± 14.0%	20.8% ± 14.0%	22.6 (12.9, 33.1)
High school	30.3% ± 8.97%	29.1% ± 10.2%	12.5 (-1.5, 28.4)
College	44.3% ± 17.6%	50.1% ± 18.9%	-15.9 (-22.0, -9.3)
<i>Employment (unemployed)</i>	8.64% ± 6.17%	6.47% ± 5.84%	41.2 (24.8, 59.9)
<i>Poverty (below poverty)</i>	19.9% ± 14.1%	13.4% ± 11.6%	39.2 (28.6, 50.7)
<i>Annual Earnings</i>			
<\$15,000	39.6% ± 13.2%	33.9% ± 11.7%	37.6 (26.2, 50.0)
\$15,000-\$29,99	30.8% ± 7.58%	28.6% ± 7.90%	44.1 (21.1, 71.5)
\$30,000-\$49,999	19.1% ± 6.73%	21.5% ± 6.43%	-42.7 (-53.0, -30.3)
≥\$50,000	10.5% ± 8.75%	16.0% ± 12.0%	-43.9 (-52.8, -33.3)

*Note:* White, black, and Asian refer to non-Hispanics. Supplemental Table 1 compares census tracts with monitors that met our exclusion criteria and tracts without monitors.

Supplemental Material Table S6. Correlation of census tract population characteristics

	White	Black	Asian	Hispanic	Other race	<20	20-64	>65	< High school	High school	College	Employment	Poverty	Earnings		
												Unemployed	Below poverty line	≥\$50,000	\$30,000-\$49,999	\$15,000-\$29,999
<i>Annual Earnings</i>																
<\$15,000	-0.43	0.35	0.06	0.17	0.14	0.01	-0.16	-0.33	0.46	-0.15	-0.28	<b>0.69</b>	<b>0.79</b>	<b>-0.61</b>	<b>-0.83</b>	-0.30
\$15,000-\$29,999	-0.18	0.17	-0.11	0.08	0.02	-0.10	-0.08	0.04	0.27	0.45	-0.45	-0.16	-0.03	-0.47	0.07	
\$30,000-\$49,999	0.50	-0.39	-0.08	-0.22	-0.13	0.00	0.13	0.26	-0.46	0.24	0.24	<b>-0.60</b>	<b>-0.73</b>	0.41		
≥\$50,000	0.42	-0.38	0.07	-0.15	-0.13	0.08	0.21	0.25	-0.57	-0.35	<b>0.63</b>	-0.45	<b>-0.61</b>			
<i>Poverty</i>	<b>-0.65</b>	0.56	0.04	0.21	0.18	-0.09	-0.22	-0.40	<b>0.63</b>	-0.13	-0.43	<b>0.66</b>				
<i>Unemployed</i>	-0.50	0.38	0.11	0.23	0.14	0.03	-0.17	-0.36	0.47	-0.13	-0.30					
<i>Education</i>																
College	0.40	-0.35	0.18	-0.23	0.08	0.07	0.22	0.12	<b>-0.86</b>	<b>-0.62</b>						
High school	0.19	0.02	-0.33	-0.25	-0.22	-0.16	-0.14	0.11	0.14							
< High school	<b>-0.63</b>	0.42	-0.01	0.45	0.04	0.02	-0.19	-0.22								
<i>Age</i>																
≥65 years	0.24	-0.23	0.01	-0.04	-0.17	0.42	0.57									
20-64 years	0.07	-0.19	0.11	0.16	-0.05	<b>0.76</b>										
<20 years	-0.08	-0.11	0.07	0.32	-0.06											
<i>Race/Ethnicity</i>																
Other race	-0.09	-0.10	0.30	0.09												
Hispanic	-0.44	-0.15	0.16													
Non-Hispanic Asian	-0.17	-0.13														
Non-Hispanic black	<b>-0.79</b>															

Note: Correlations are not shown for mutually exclusive binary categories (employment, poverty). For example, correlations between a population characteristics and the percentage unemployed is -1x the correlation with the percentage employed. White, black, and Asian refer to non-Hispanics. Values that are ≥0.6 or ≤-0.6 are bolded,